



ALBERT-LUDWIGS-
UNIVERSITÄT FREIBURG

Algorithms for Radio Networks

MACA

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Problem of Wireless Media Access

- **Unknown number of participants**
 - broadcast
 - many nodes simultaneously
 - only one channel available
 - asymmetric situations
- **Collisions produce interference**
- **Media Access**
 - Rules to participate in a network

Aims

- **Delay**
- **Throughput**
- **Fairness**
- **Robustness and stability**
 - against disturbances on the channel
 - against mobility
- **Scalability**
- **Energy efficiency**

Methods

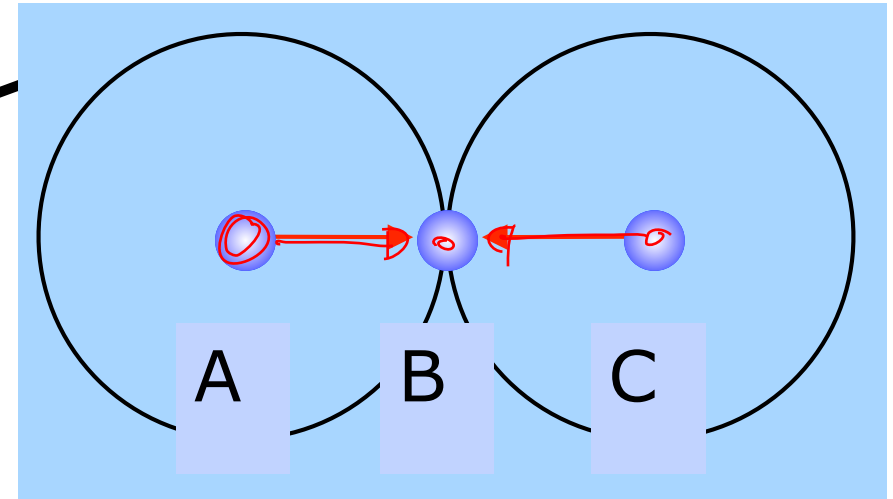
- **Organisation**
 - Central control
 - Distributed control
- **Access**
 - without contention
 - with contention

Problem of Media Access

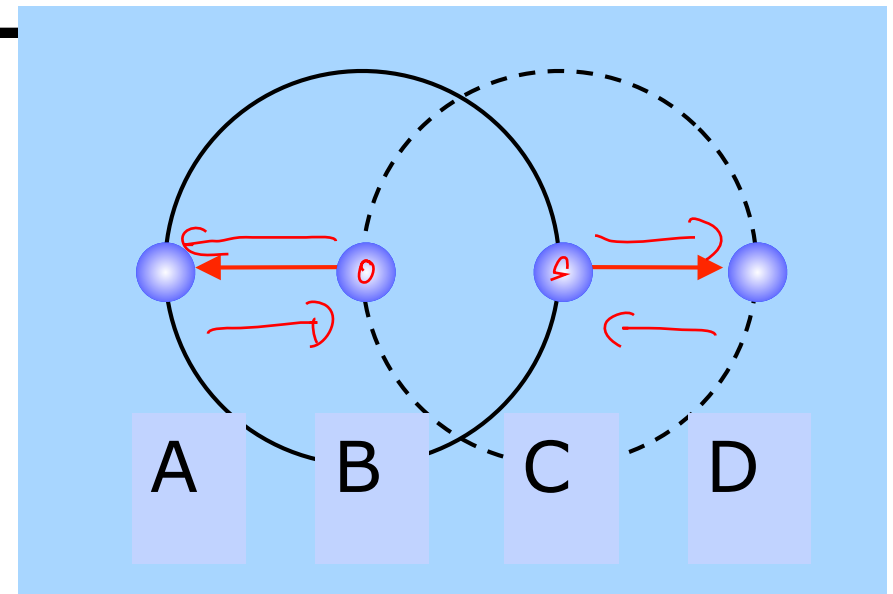
- ▶ **CSMA/CD not applicable**
 - Media is only locally known
 - Bounded range
- ▶ **Hidden Terminal**
 - Receiver collision despite *carrier sensing*
- ▶ **Exposed Terminal**
 - Opportunity costs of unsent messages because of *carrier sensing*

Hidden Terminal and Exposed Terminal Problem

Hidden Terminal Problem



Exposed Terminal Problem



Alternative Solutions

- ▶ **Extended hardware**
 - Addition carrier signal blocks and ensures transmission
- ▶ **Centralized solution**
 - Base station is the only communication partner
 - Base station coordinates the media access

MACA

RTS/CTS

► Phil Karn

- MACA: A New Channel Access Method for Packet Radio 1990

► Alternative names:

- Carrier Sensing Multiple Access / Collision Avoidance (CSMA/CA)
- Medium Access with Collision Avoidance (MACA)

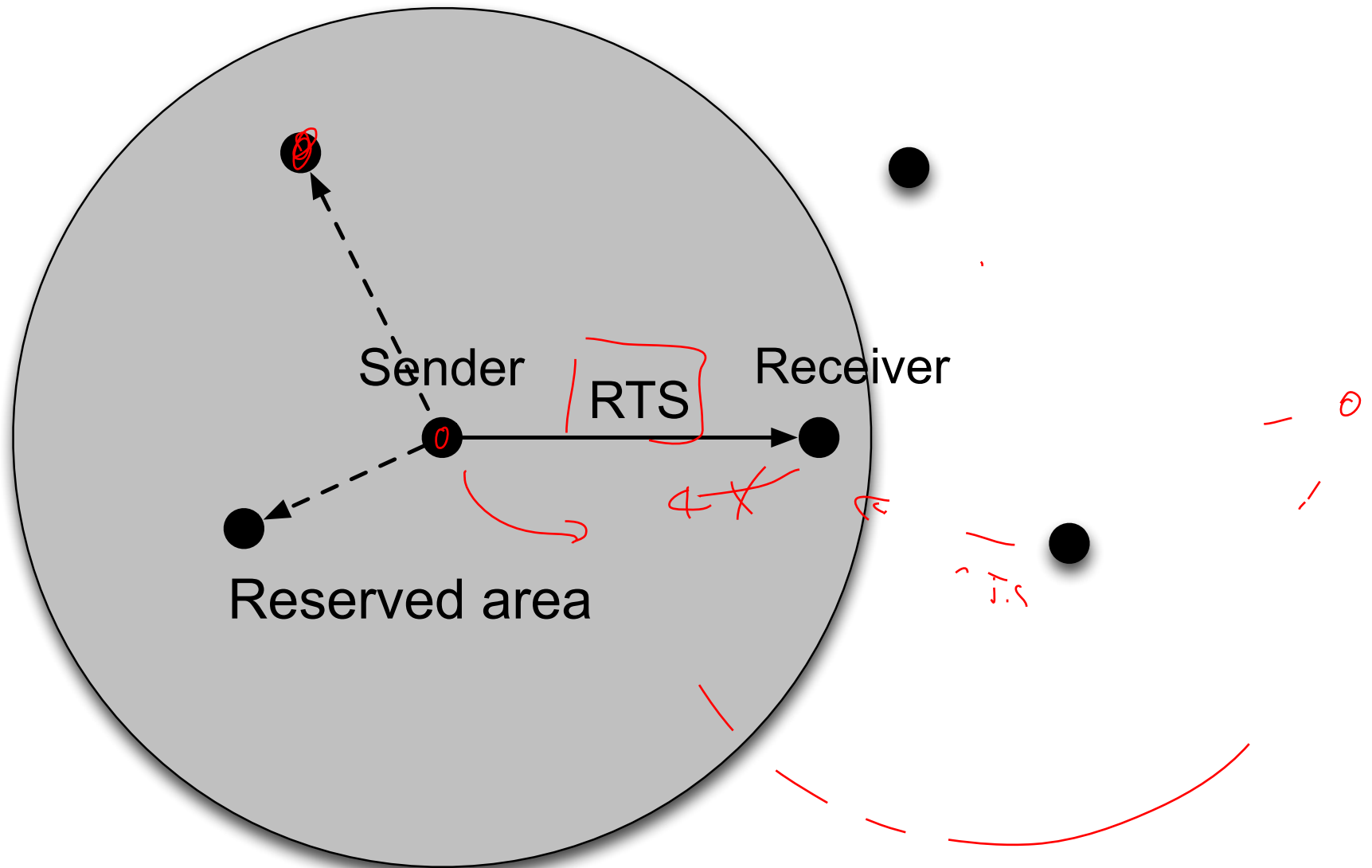
► Aim

- Solution of the Hidden and Exposed Terminal Problem

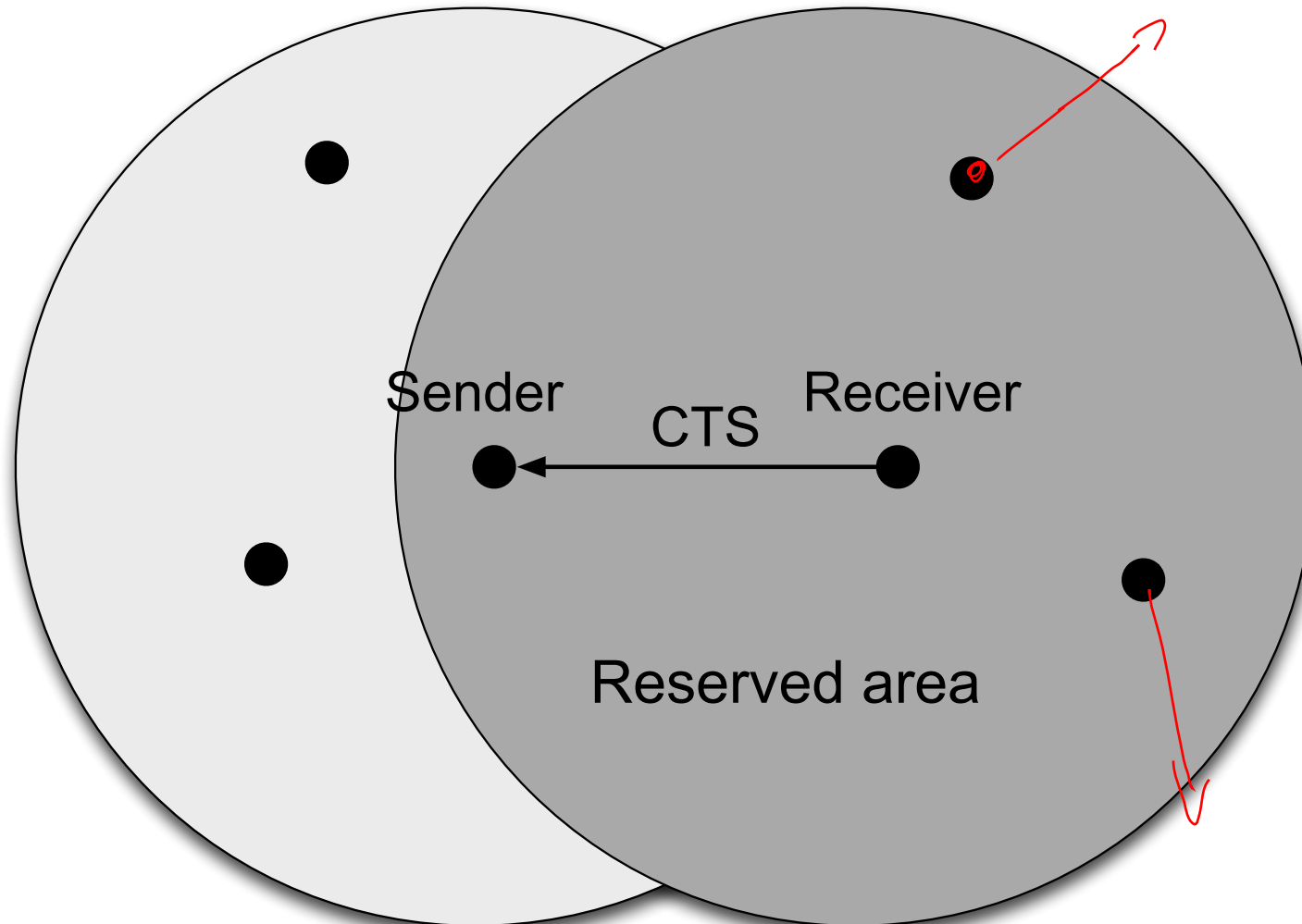
► Idea

- Channel reservation before the communication
- Minimization of collision cost

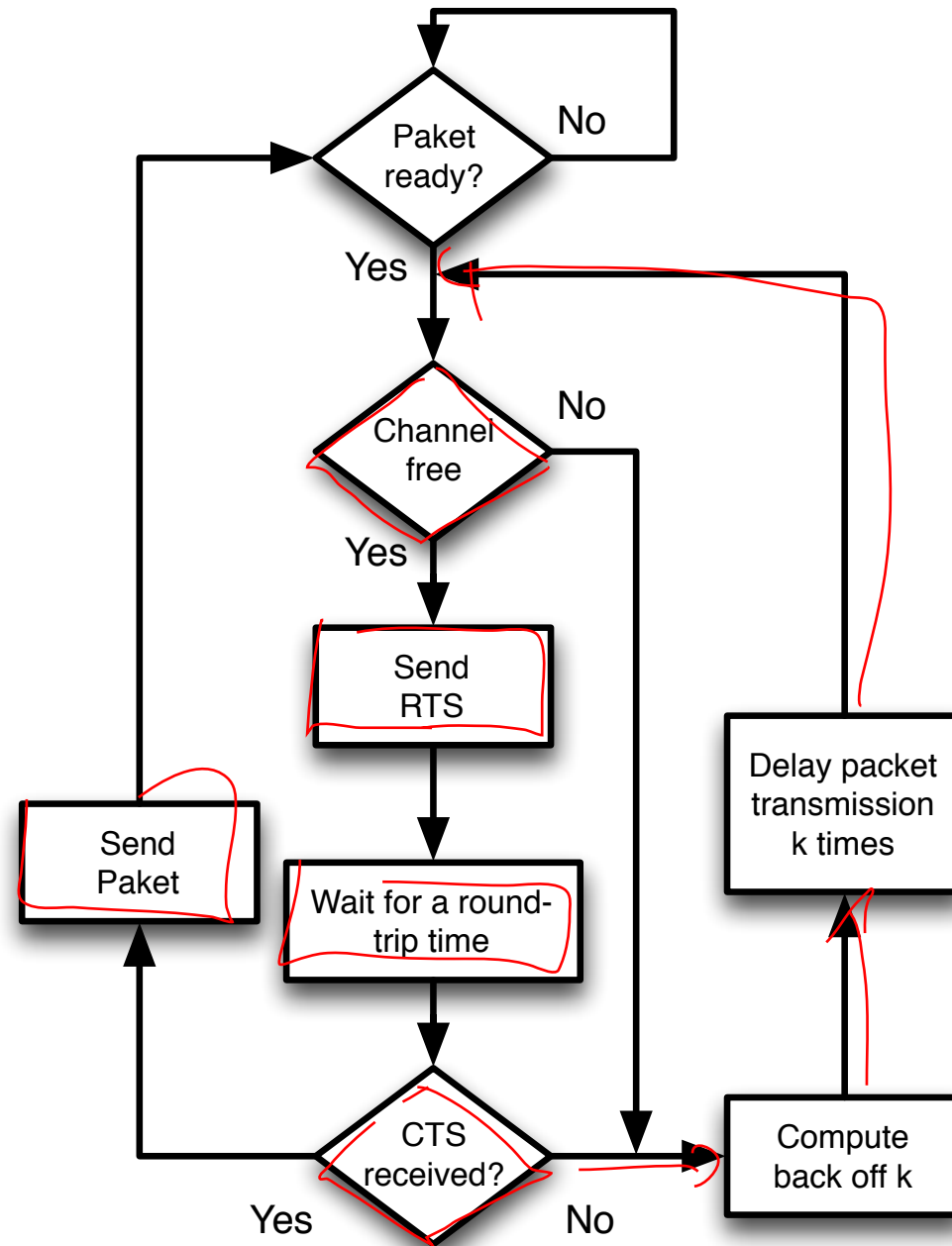
Request to Send



Clear to Send



RTS/CTS MACA CSMA/CA



Details for Sender

- ▶ **A sends RTS**
 - waits certain time for CTS
- ▶ **If A receives CTS in time**
 - A sends packet
 - otherwise A assumes a collision at B
 - doubles Backoff-counter
 - and chooses a random waiting time from $\{1, \dots, \text{Backoff}\}$
 - After the waiting time A repeats from the beginning

Details for Receiver

- ▶ **After B has received RTS**
 - B sends CTS
 - B waits some time for the data packet
 - If the data packet arrives then the process is finished
 - Otherwise B is not blocked

Details for Third Parties

- ▶ **C receives RTS of A**
 - waits certain time for CTS of B
- ▶ **If CTS does not occur**
 - C is free for own communication
- ▶ **If CTS of B has been received**
 - then C waits long enough such that B can receive the data packet

Details for Third Parties

► D receives CTS of B

- waits long enough such that B can receive the data packet

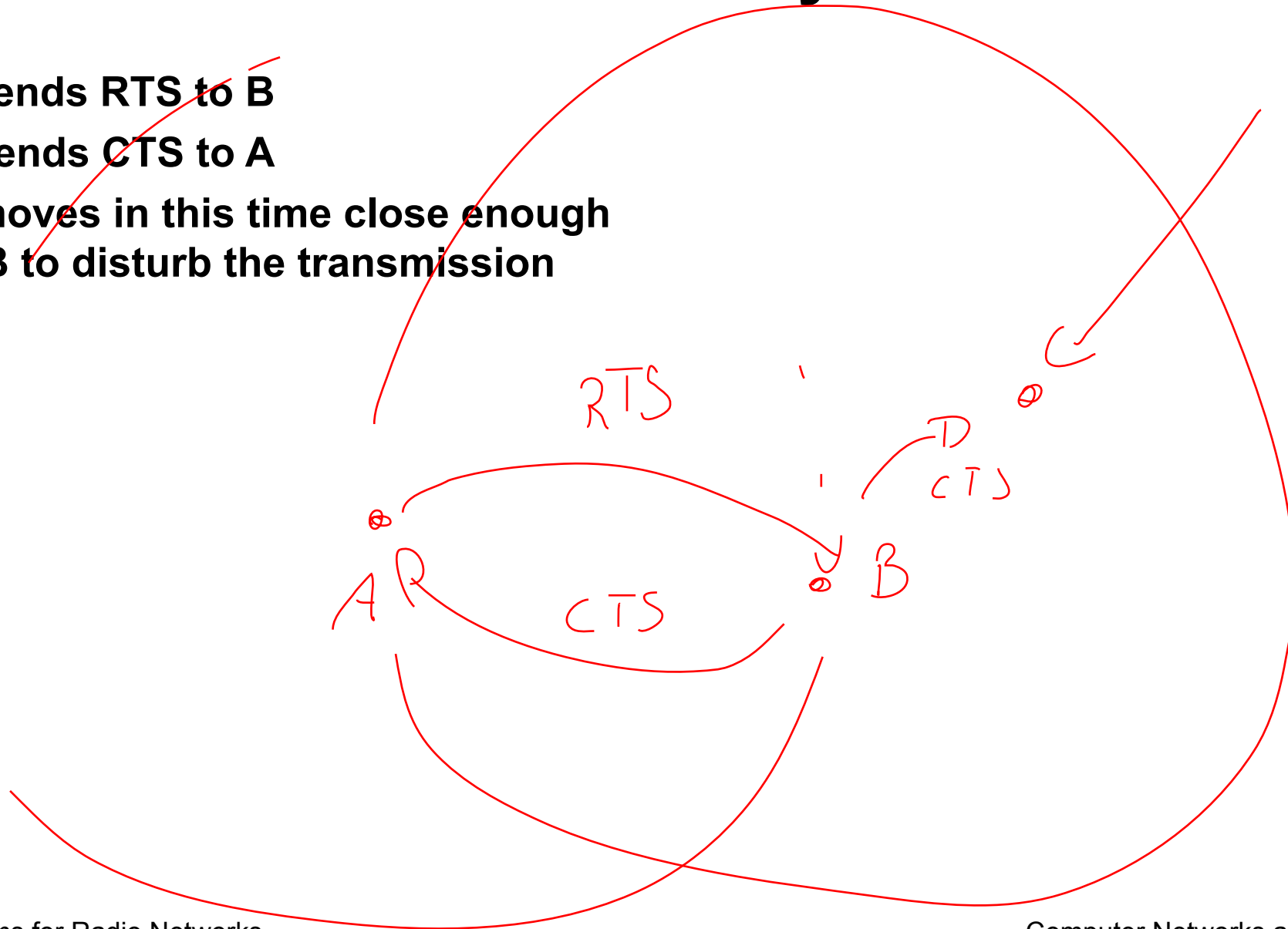
► E receives RTS of A and CTS of B

- waits long enough such that B can receive the data packet



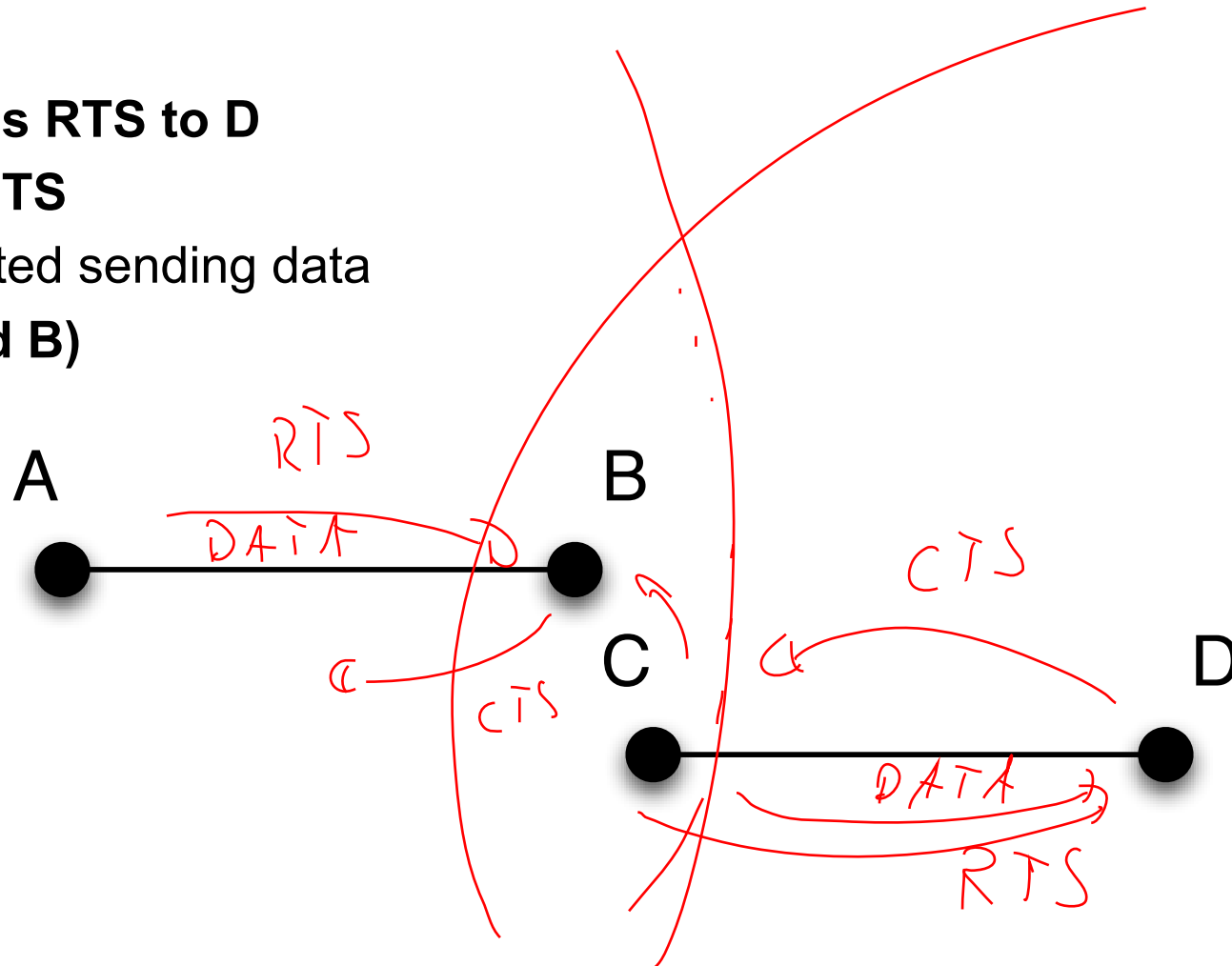
Hidden Terminal because of Mobility

- ▶ A sends RTS to B
- ▶ B sends CTS to A
- ▶ C moves in this time close enough to B to disturb the transmission



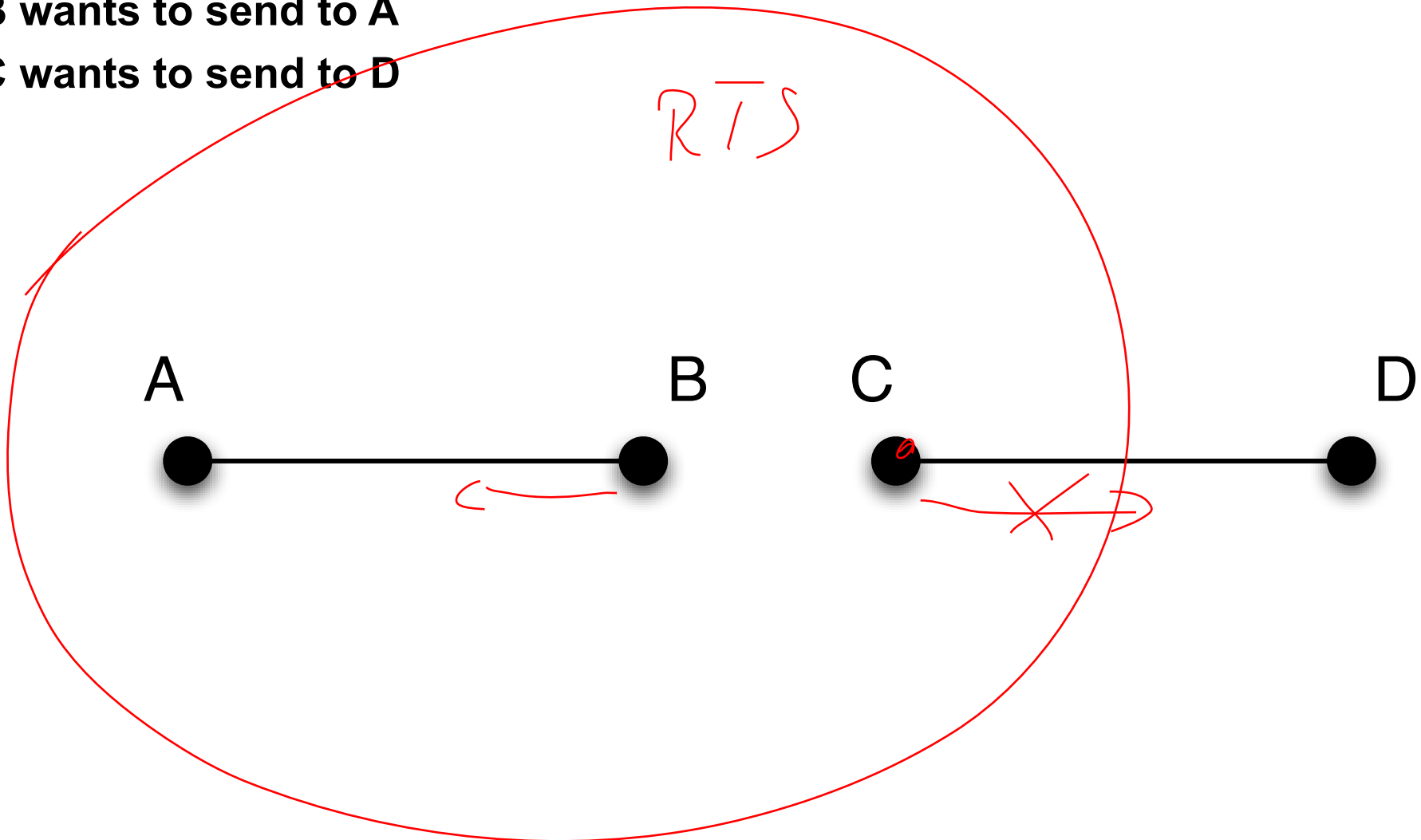
Hidden Terminal the parallel case

- ▶ A sends RTS to B
- ▶ B sends CTS
- ▶ In parallel C sends RTS to D
- ▶ D answers with CTS
 - while A has started sending data
- ▶ C sends to D (and B)



Exposed Terminals in MACA

- B wants to send to A
- C wants to send to D



Conclusions

► MACA

- solves the Hidden Terminal Problem only partially
- Exposed Terminal Problem is not solved



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